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Title: Performance of the Los Alamos National Laboratory spallation-driven solid-deuterium ultra-cold neutron source

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Performance of the Los Alamos National Laboratory spallation-driven solid-deuterium ultra-cold neutron source

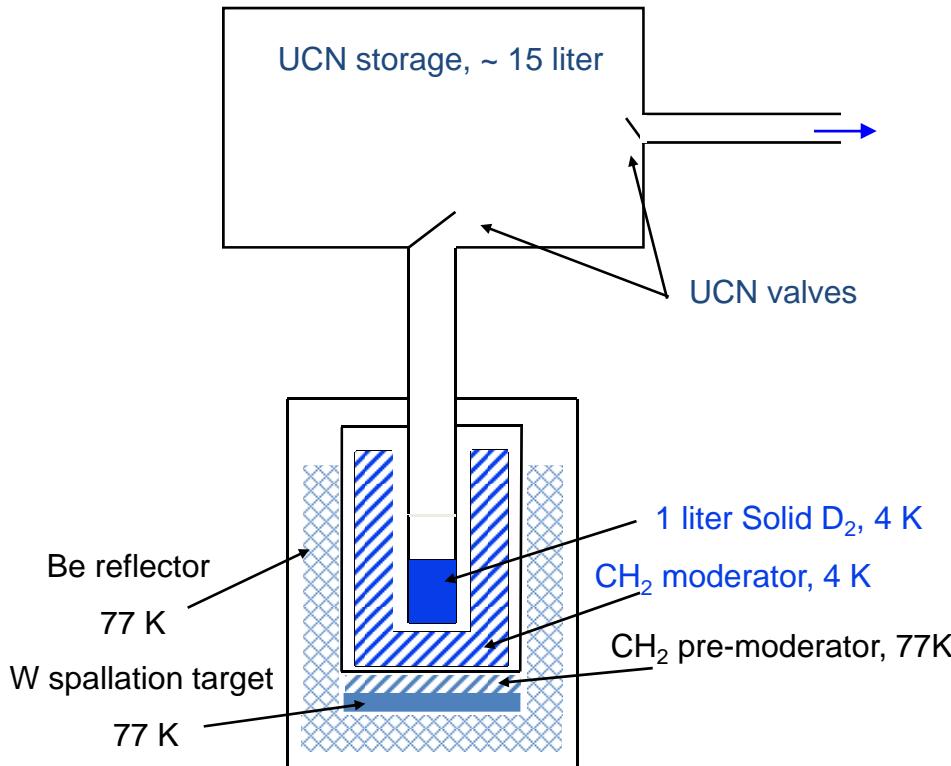
C. L. Morris for the UCNA Collaboration

Los Alamos National Laboratory

10/24/2012

the performance of the Los Alamos spallation-driven solid-deuterium Ultra Cold Neutron (UCN) source is described. Measurements of the cold neutron flux, the very low energy neutron production rate, and the UCN rates and density at the exit from the biological shield are presented and compared to Monte Carlo predictions. The cold neutron rates compare well with predictions from the Monte Carlo code MCNPX and the UCN rates agree with our custom UCN Monte Carlo code. The source is shown to perform as modeled. The maximum delivered UCN density at the exit from the biological shield is 52(9) UCN/cc with a solid deuterium volume of \sim 1500 cm³.

Solid D₂ Spallation UCN Source Concept



- SD2 source †
 - SD₂ has a large down scattering rate R
 - Cold SD₂ is predicted to have small absorption and up scattering cross sections-> long UCN lifetime τ
 - UCN density, Rτ, is predicted to be large.
- Spallation driver‡
 - High cold neutron density
 - Shutter source

†R. Golub and K Boning, Z. Phys. B **51**, 187 (1993).

‡A. Serebrov, "First UCN Factory Workshop" Jan 18-22, 1988, Puskin, Russia.

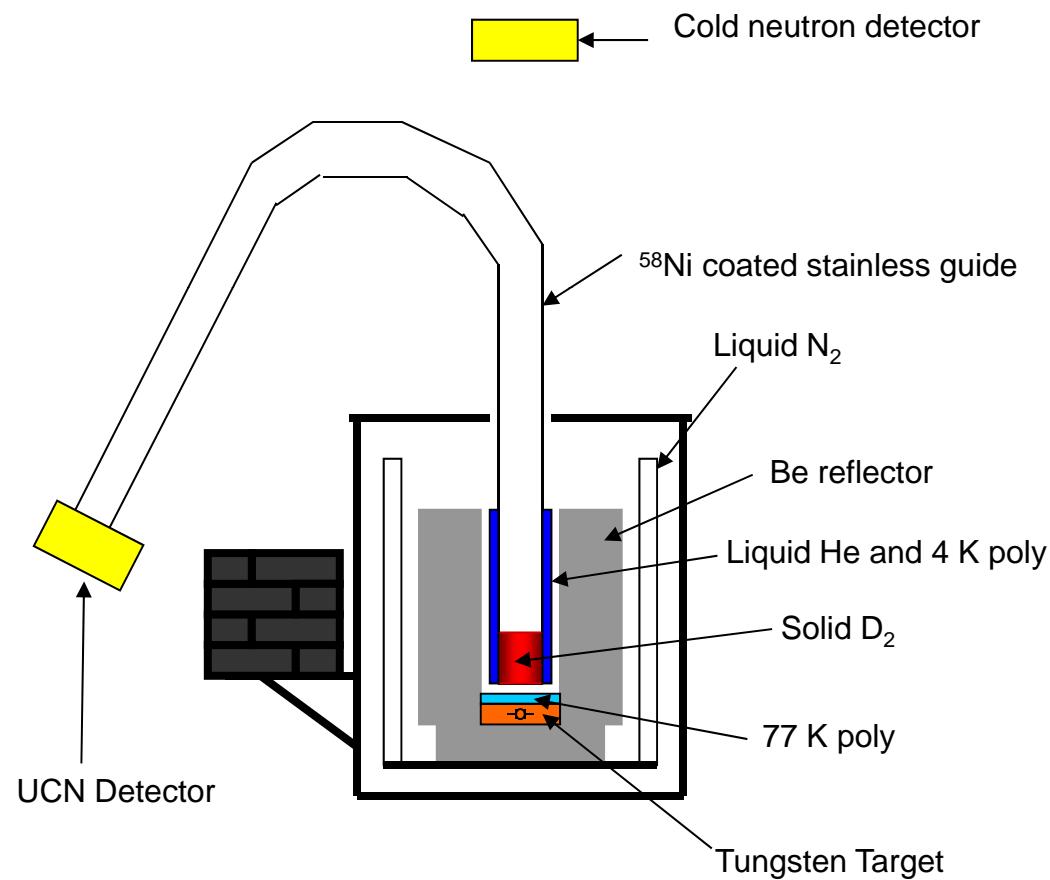
$$\tau \approx \frac{V}{V_{SD2}} \tau_{SD2}$$

$$\rho(t > \tau) \approx \rho(SD_2)$$

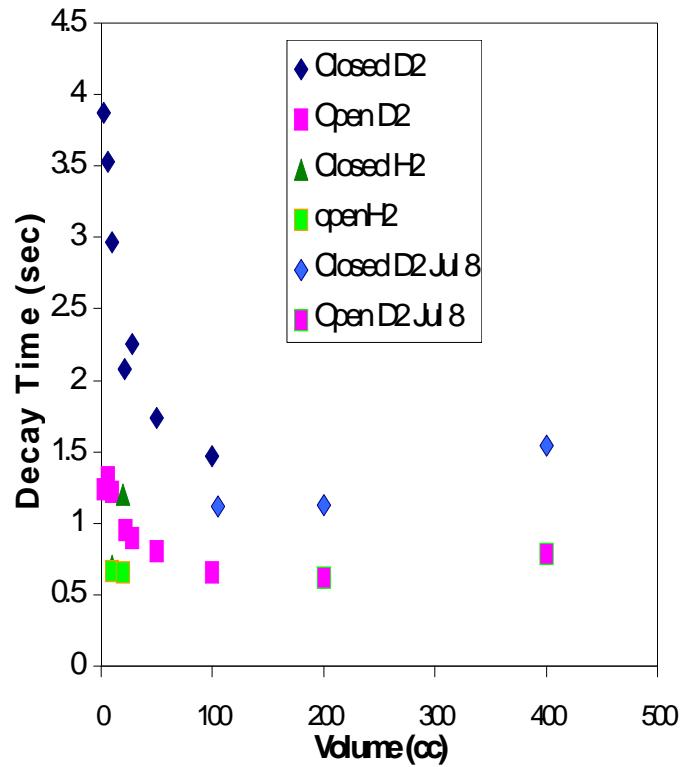
$$\tau_{SD2} = 160 \text{ msec (absorption)}$$

$$V_{SD2} = 102 \text{ nV}$$

UCN Measurements in Blue Room



UCN Measurements in Blue Room



- Significant UCN fluxes are produced from 50 cm² SD₂.
- SD₂ lifetime looks shorter than expected even for 10 k up-scatter cross section..
 - Temperature?
 - Other up-scatter mechanisms?

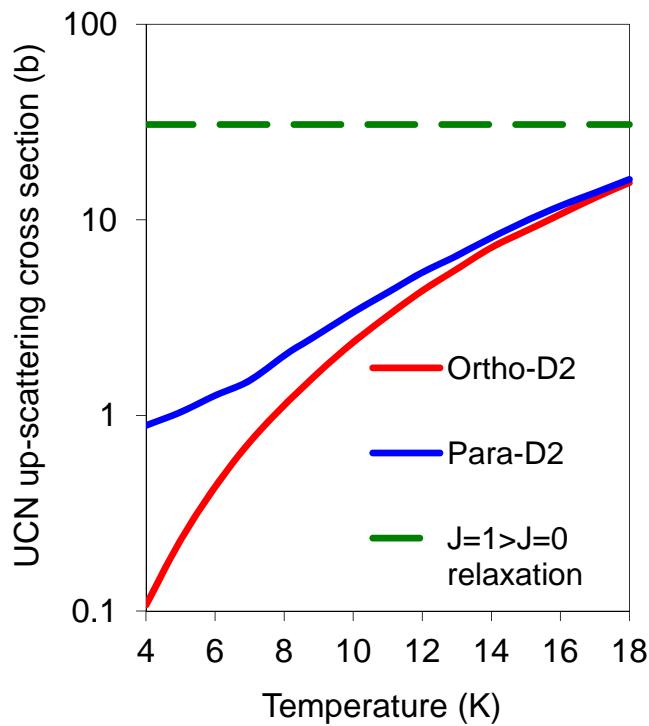
Solid Model[†] (solution to the lifetime puzzle)



Para to ortho converter
17 K ferric hydroxide

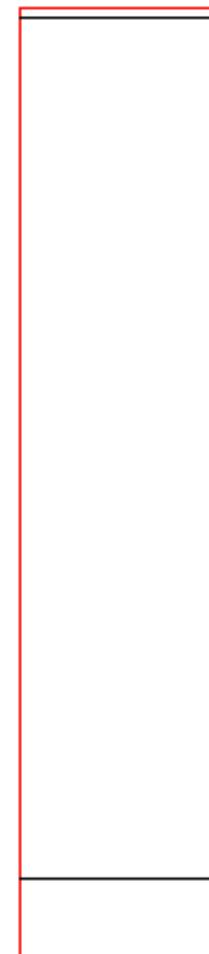
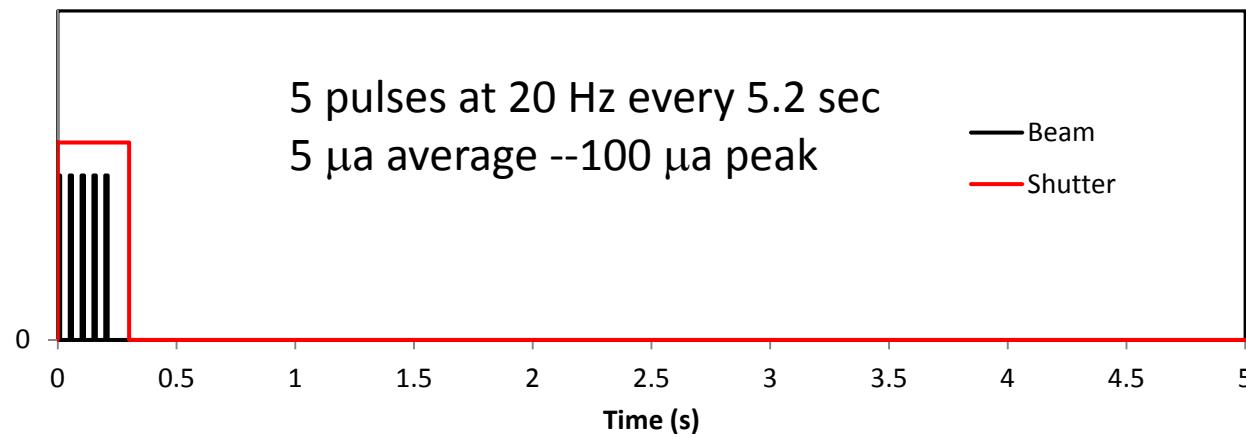
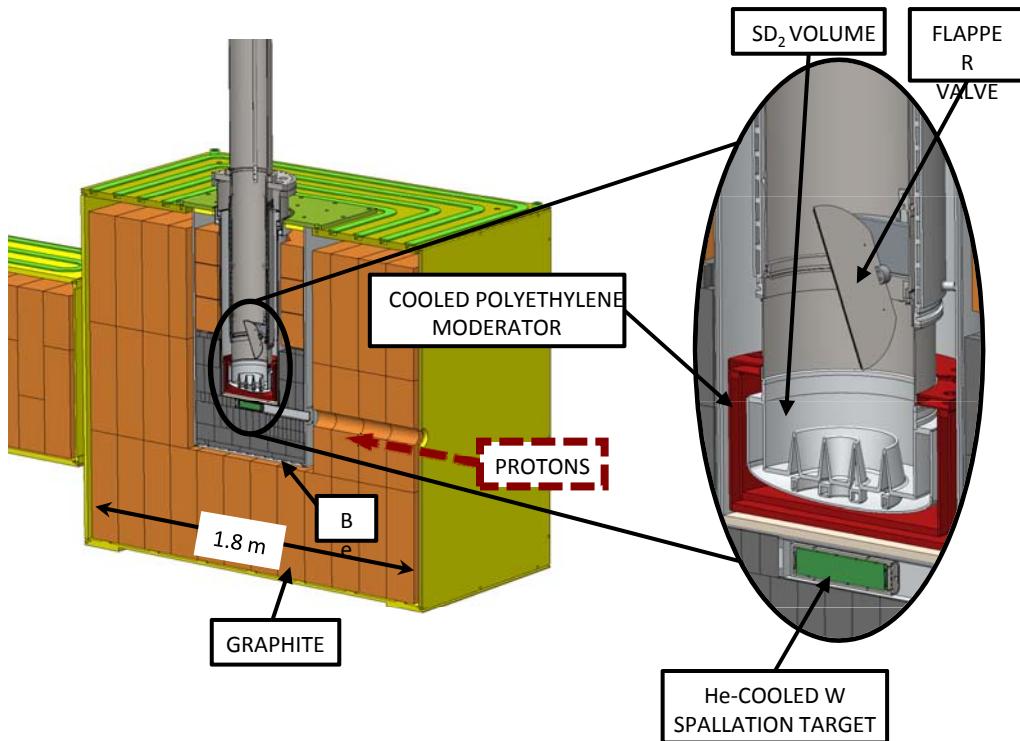
Radiation exposure catalyzes conversion
~1% Para after 2 months of running

- 150 msec
 - $n+D \rightarrow \gamma+t$
 - 0.2 %HD
 - 2% Para
 - 5 K temperature

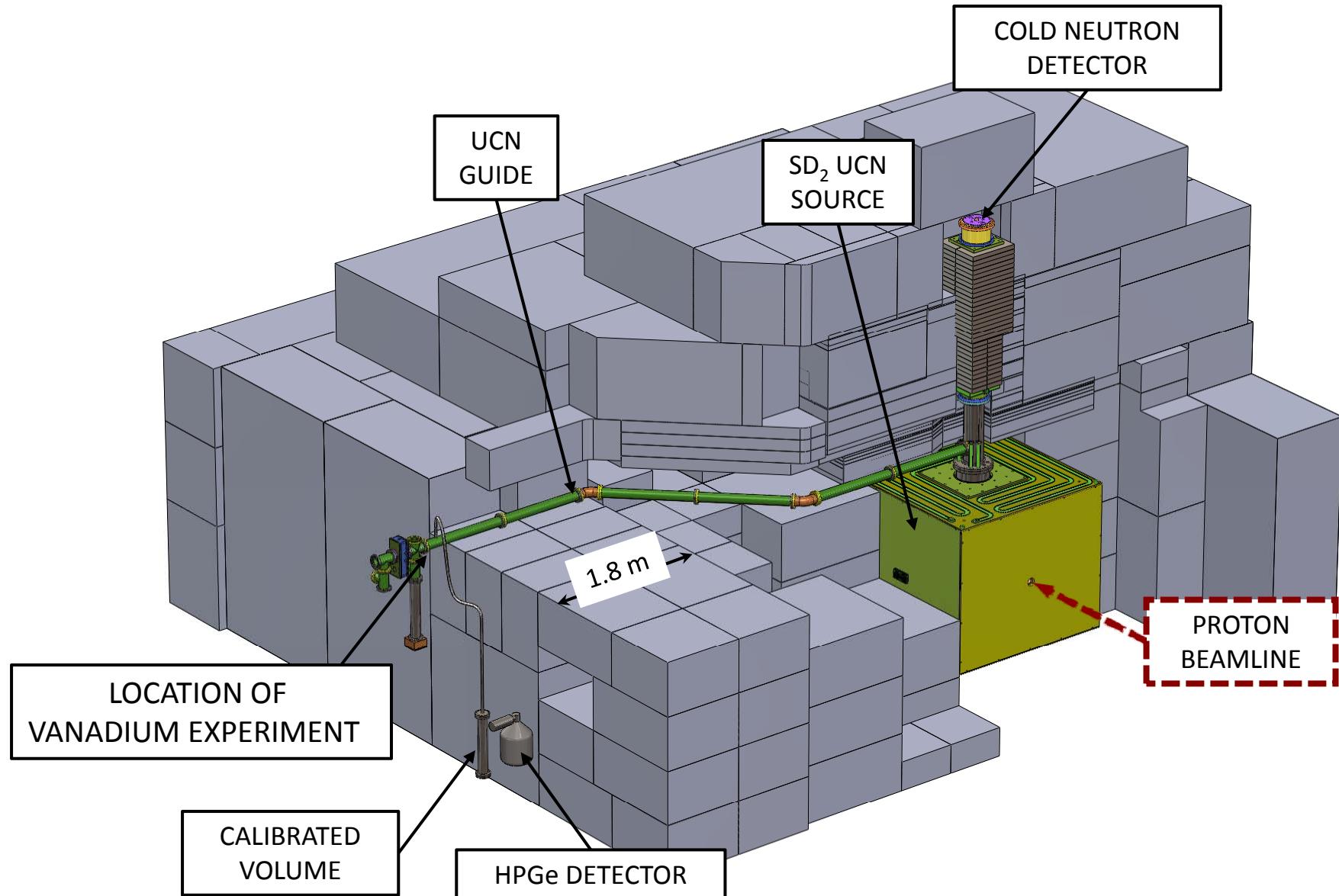


[†]C.Y. Liu, A. R. Young and S. K. Lamoreaux, Phys. Rev B **62** (6), R3581-R3583 (2000)

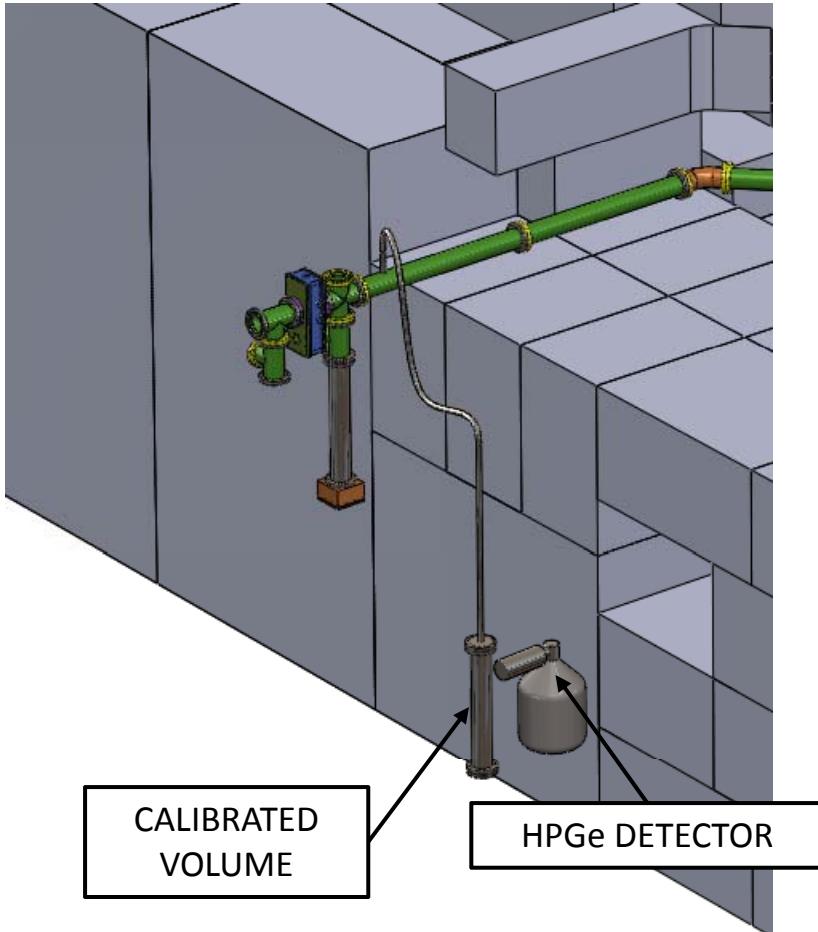
Source operation



Layout



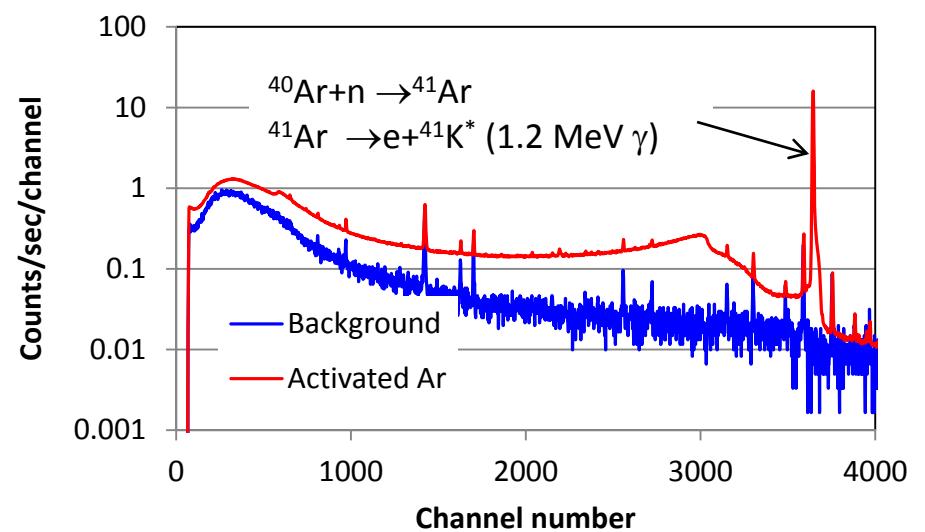
Cold neutron flux



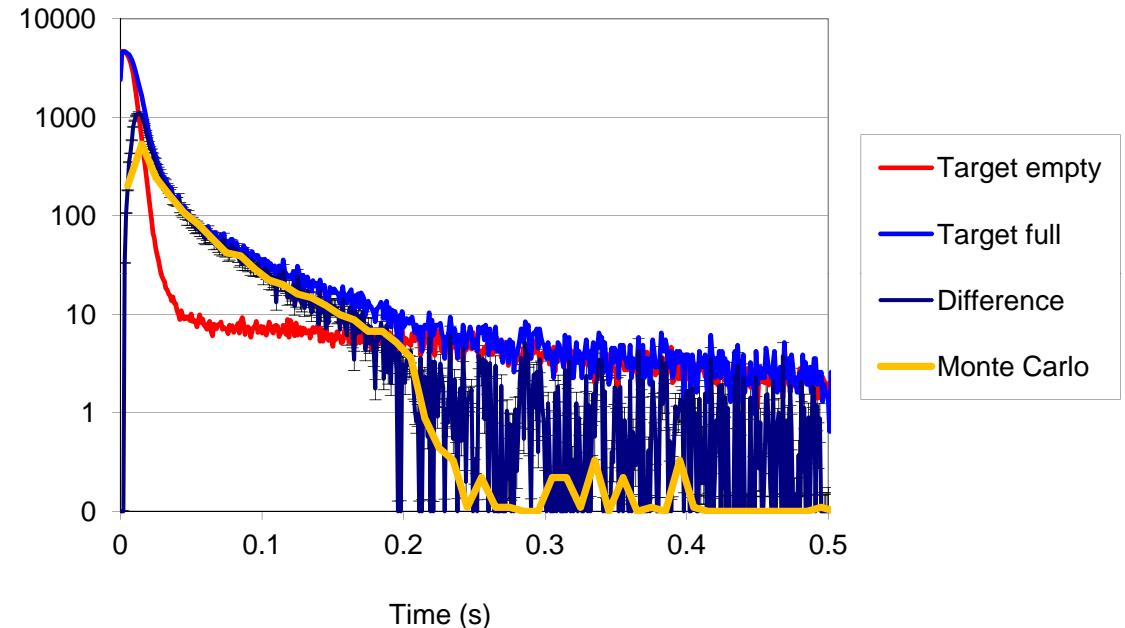
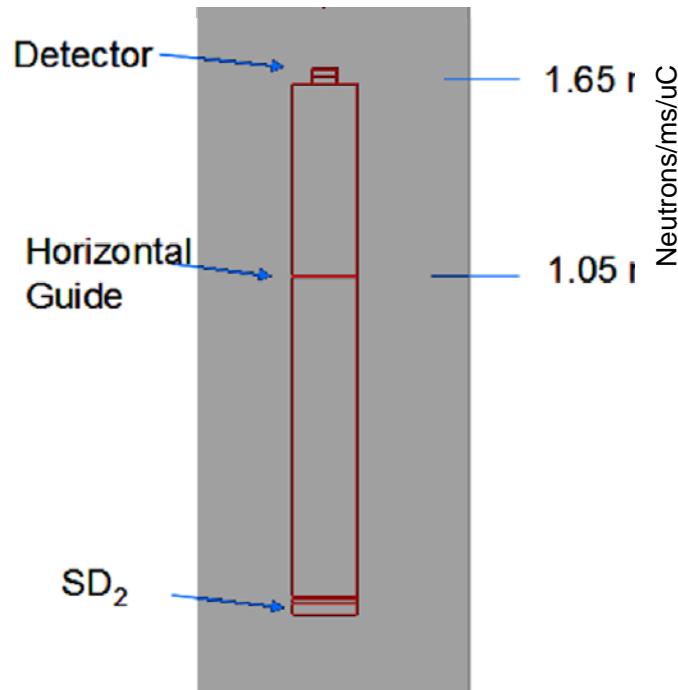
^{41}Ar		
σ	0.68	b
τ	9487	s

Ar activation

- Cold neutron flux of 0.84 ± 0.17 neutrons/proton
- Flux density of $(1.7 \pm 0.3) \times 10^{10}$ CN/cm²/mA.
- Peak neutron flux was about 1.33×10^{13} CN/cm².

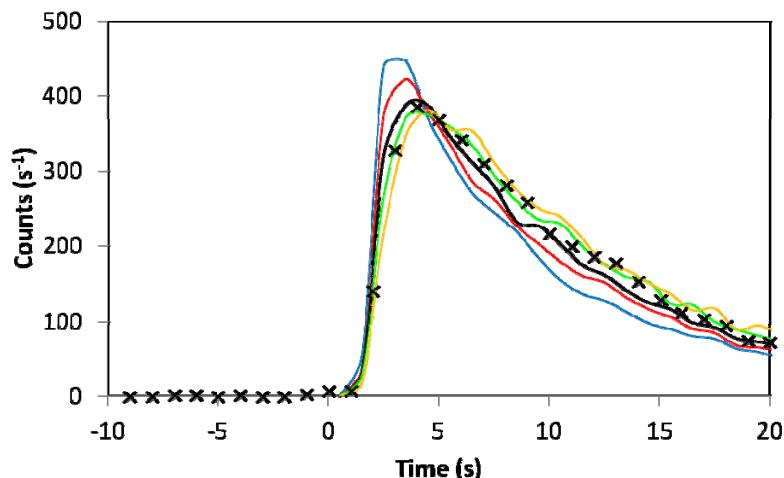


UCN production-internal measurements



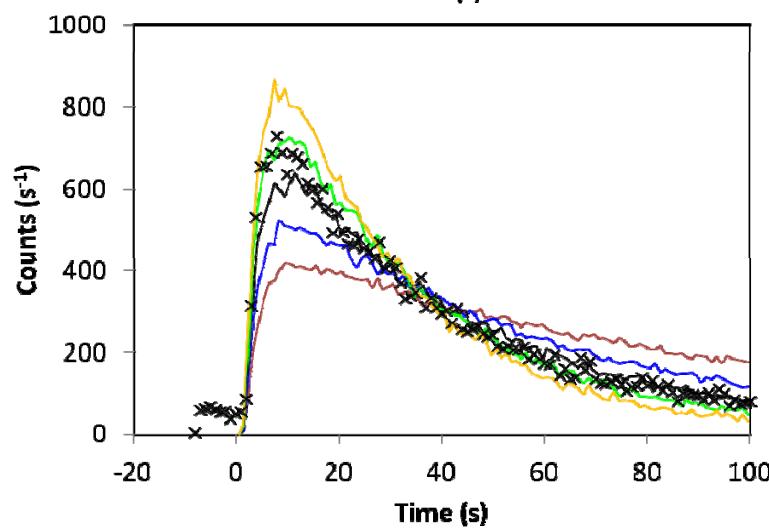
- Monte Carlo production up to 100 m/s
- Normalize production rate to the VCN spectrum
- $85 \pm 10 \text{ UCN}/\mu\text{C}/\text{cm}^3$
- This production rate agrees with the known cross sections convolved with the cold neutron flux ~20%

Transport-single pulse UCN measurements. Gate valve closed monitor detector measurements



Flapper open-
sensitive to guide
specularity
 $3.0(5) \times 10^{-2}$

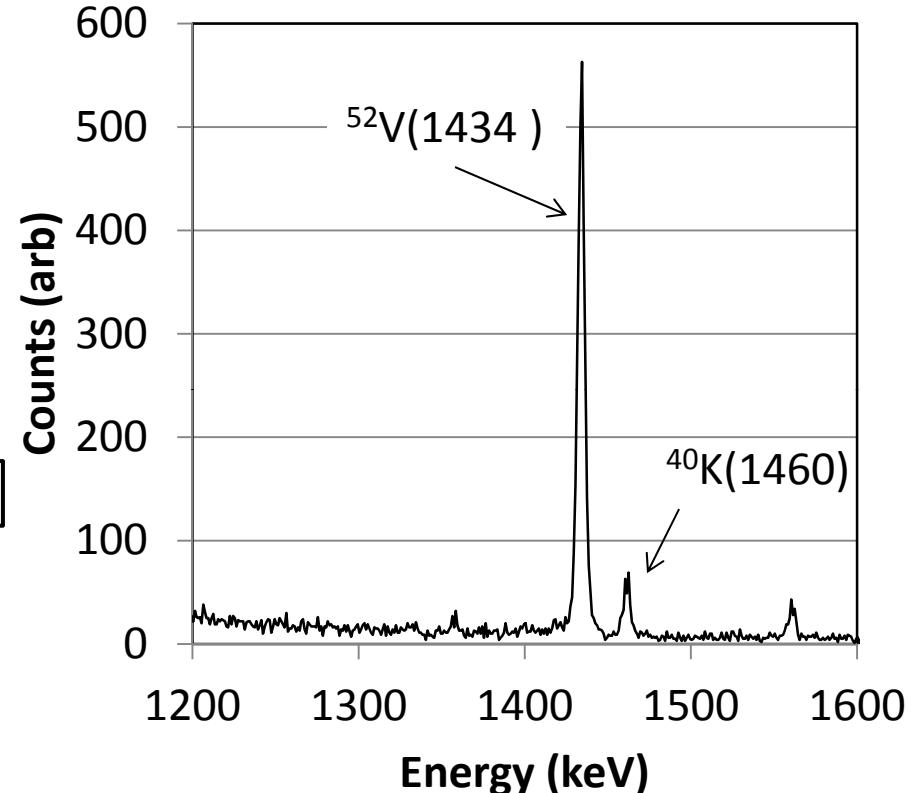
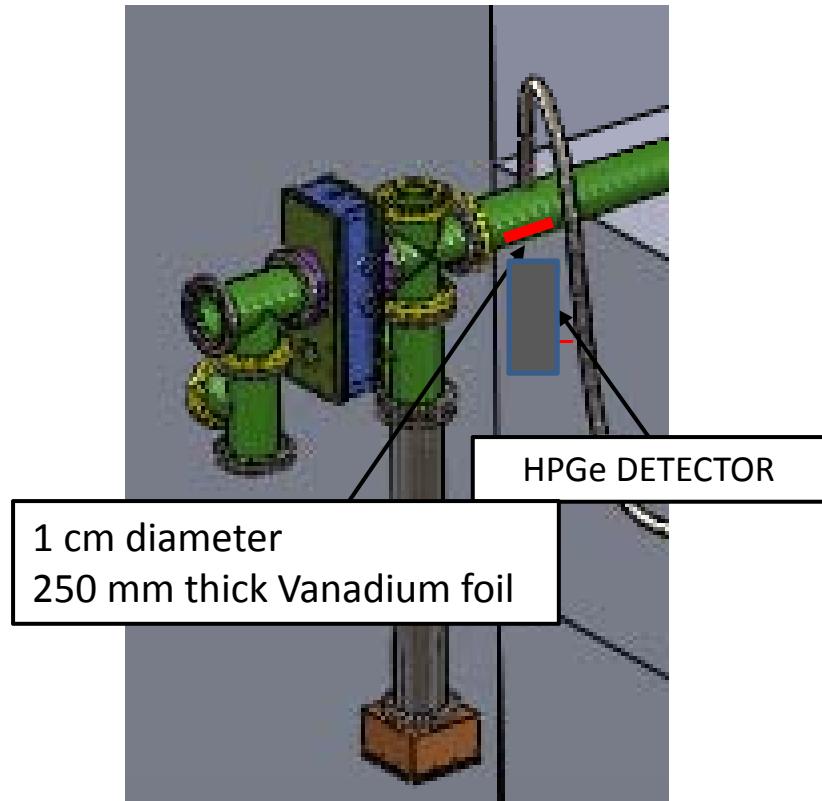
Production rates:
60(12) UCN/ μ C/cm³ 2009
100(20) UCN/ μ C/cm³ 2010



Flapper closed-
sensitive to
guide loss
 $3.5(1) \times 10^{-4}$

Monte-Carlo transport
Measured production Predict
48(10) UCN/cm³ 2009
79(16) UCN/cm³ 2010

Direct Density Measurements



$V_F = -7 \text{ nV}$
 $\sigma = 5.08 \text{ b}$,
 $\tau_{UCN} = 1.2 \times 10^{-5}$
 $\tau_{^{52}\text{V}} = 324 \text{ s}$

$$\rho_{UCN} = \frac{4R}{a\bar{v}}$$

Monte-Carlo transport+
Measured production Predict
48(10) UCN/cm³ 2009
79(16) UCN/cm³ 2010
Direct Measurement
52(9) UCN/cm³ 2010

LANL UCN Source

- Measurements validate source performance agrees with expectations
- Provides 52(9) UCN/cm³ for experiments
 - UCN A
 - UCN B
 - UCN b
 - UCN τ